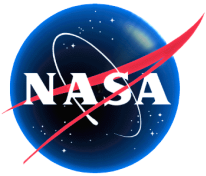


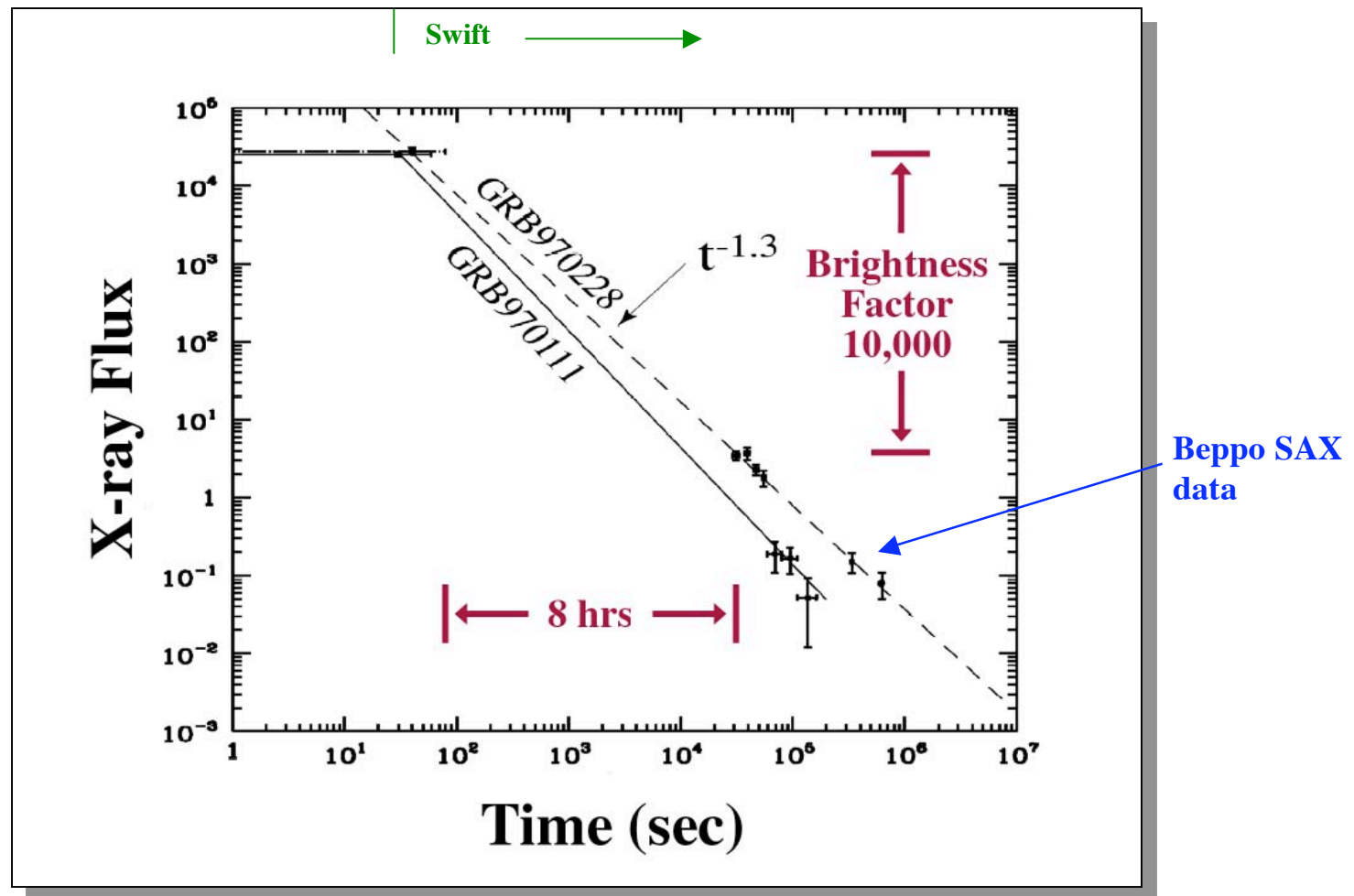
# Gamma-Ray Burst Operations:

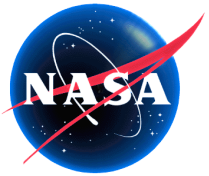
*A Multiwavelength Observatory for Rapid-Response Observations of Transient Targets*

John Nousek (Penn State University)



# The Time Gap



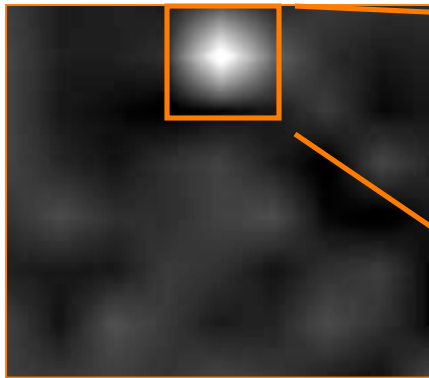


# Observing Scenario



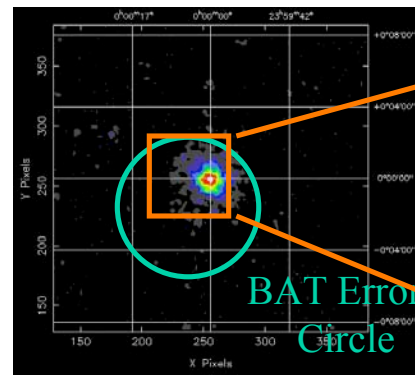
1. Burst Alert Telescope triggers on GRB, calculates position on sky to  $< 4$  arcmin
2. Spacecraft autonomously slews to GRB position in 20-70 s
3. X-Ray Telescope determines position to  $\sim 3$  arcseconds
4. UV/Optical Telescope images field, transmits finding chart to ground

BAT Burst Image



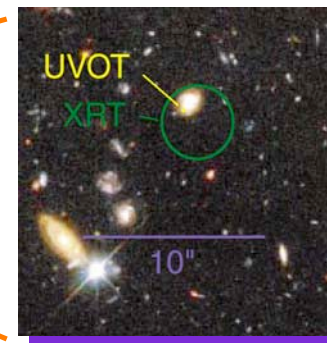
*T < 10 sec*

XRT Image

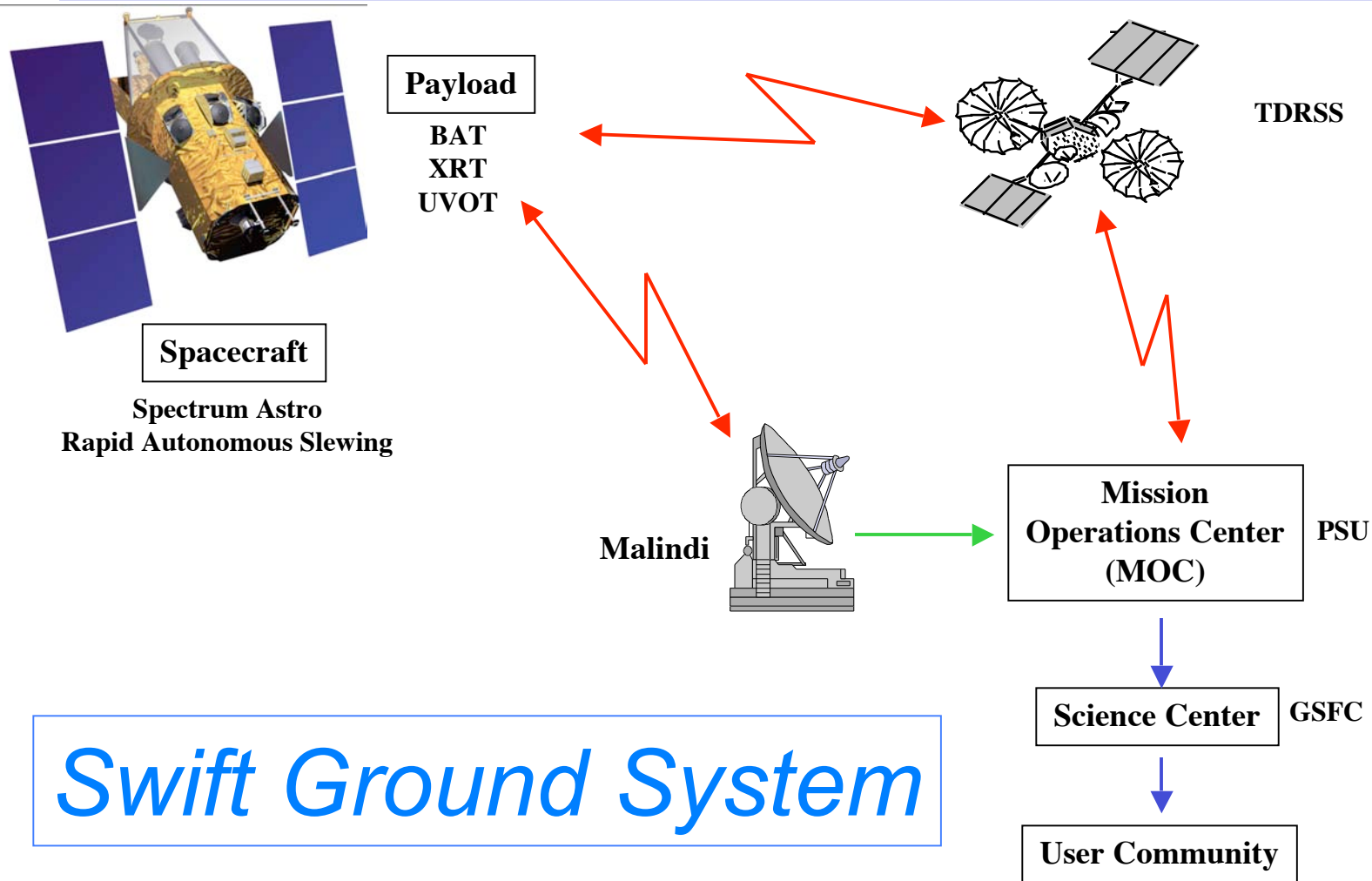
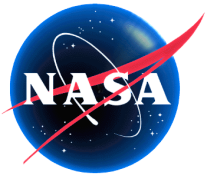


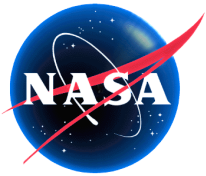
*T < 90 sec*

UVOT Image



*T < 300 sec*





# MOC Design: Automation



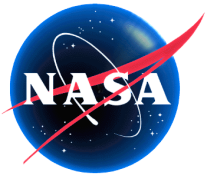
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## Automation Used Advantageously

- Flight Ops
  - Pass Execution
  - Telemetry Processing
  - Health and Safety Monitoring
- 24-hour Paging of Flight and Science Ops Personnel for:
  - GRB Alerts
  - Spacecraft, Instrument, and Ground System Anomalies
- Science Ops
  - Fast Data Processing for Planners (As Well As the Community)
  - Efficient Revision of Mission Timelines for New GRBs

⇒ *Small Operations Team and Single Shift, 40-hour Week*

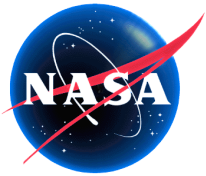
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# MOC: Normal Operations



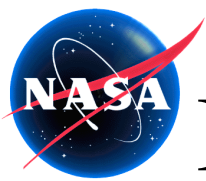
- Regular Weekday Activities Include:
  - Science Planner Develops 5-day Target List for Afterglow Follow-up
  - Planning Engineer Incorporates Into Mission Timeline
- Capability for Unusual Circumstances
  - Planner and Engineer May Make Unscheduled Timeline Revisions for:
    - Unusual GRB Behavior
    - Scientific Interest Greater than GRBs in 5-day Timeline
    - Time-Critical ToOs
  - Flight and Science Ops Personnel are On-call 24 Hours
    - Paged for GRBs (and Anomalies)
    - Review Data Via Remote ITOS Display



# Burst Alert Distribution



- Function
  - Swift Rapidly Distributes GRB Alerts to the Community
  - There Are 7 Different Alerts Including:
    - BAT Position (Expected Delay from Burst to Distribution is 8 s)
    - XRT Position (96 s)
    - UVOT Finding Chart (243 s)
- Implementation
  - Distribution Utilizes TDRSS & GRB Coordinates Network (GCN)
  - TDRSS Data are Shipped Directly to GCN Computer at GSFC
  - Distribution is Automatic



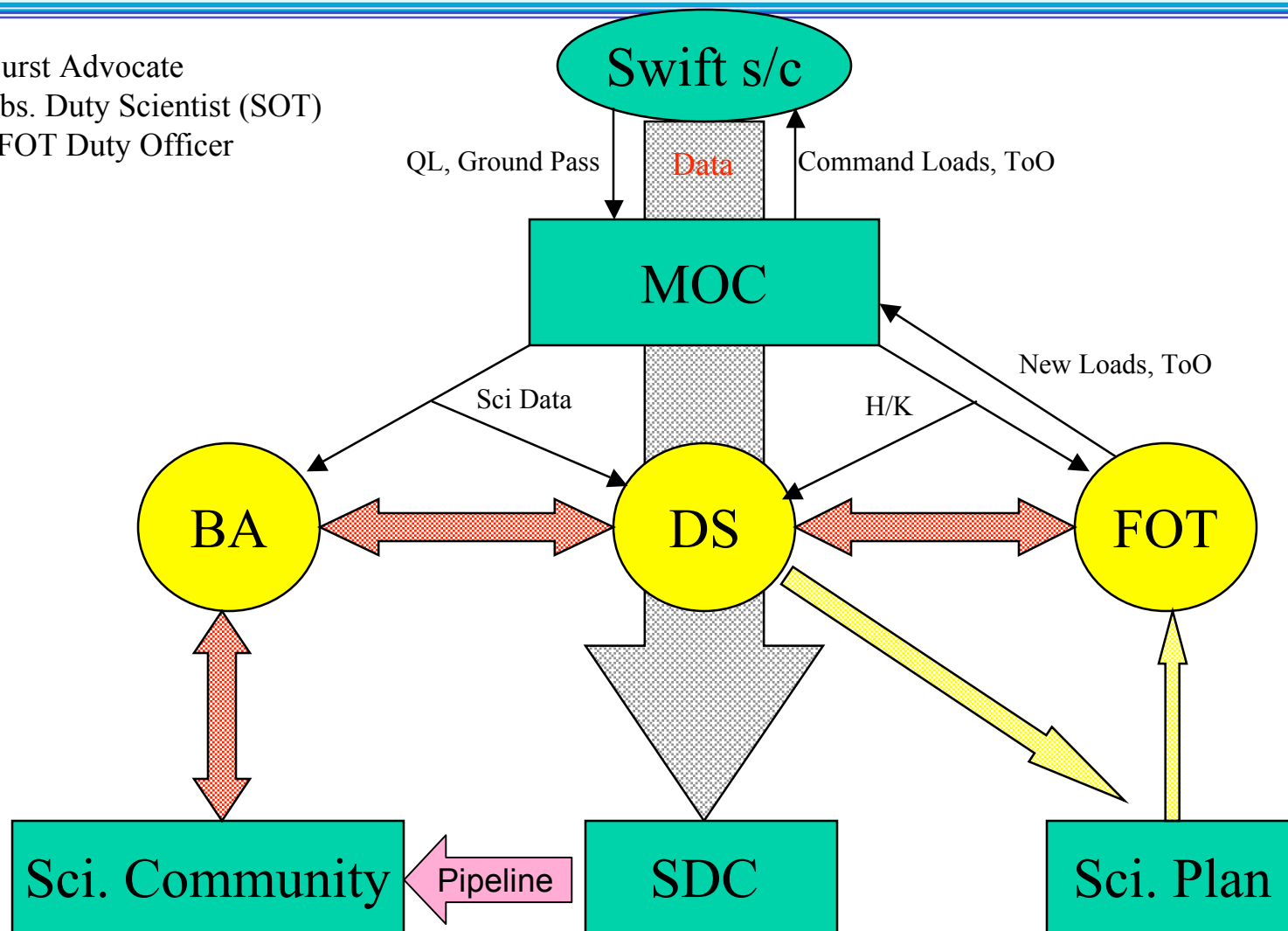
# Immediate Response to GRBs



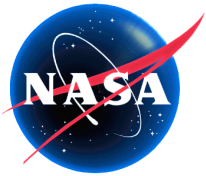
BA: Burst Advocate

DS: Obs. Duty Scientist (SOT)

FOT: FOT Duty Officer

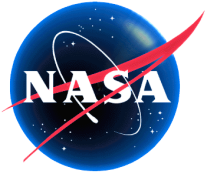






# Observatory Duty Scientist

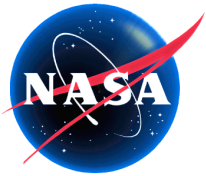
- ODS responsibilities:
  - Chair daily science operations planning meeting
  - Coordinate inputs from instrument teams, FOT, and Burst Advocates
  - Verify that data reaches SDC
  - Enter shift report daily
  - Evaluate TOOs for feasibility and time-criticality (on-call)
  - Support emergency GRB scheduling when required (on-call)
  - Support observatory anomaly investigations and recovery (on-call)
  - Respond to GRB alerts (on-call)
  - Respond to FoM TDRSS Emergency messages (on-call)
- ODS Personnel (all at PSU):
  1. John Nousek (NFI PI; Mission Directory)
  2. Marg Chester (MOC Lead)
  3. Pete Roming (UVOT Lead)
  4. Joanne Hill (XRT Instrument Scientist)
  5. Jamie Kennea (XRT Scientist)
  6. Sally Hunsberger (UVOT Instrument Scientist)



# Swift Science Planner



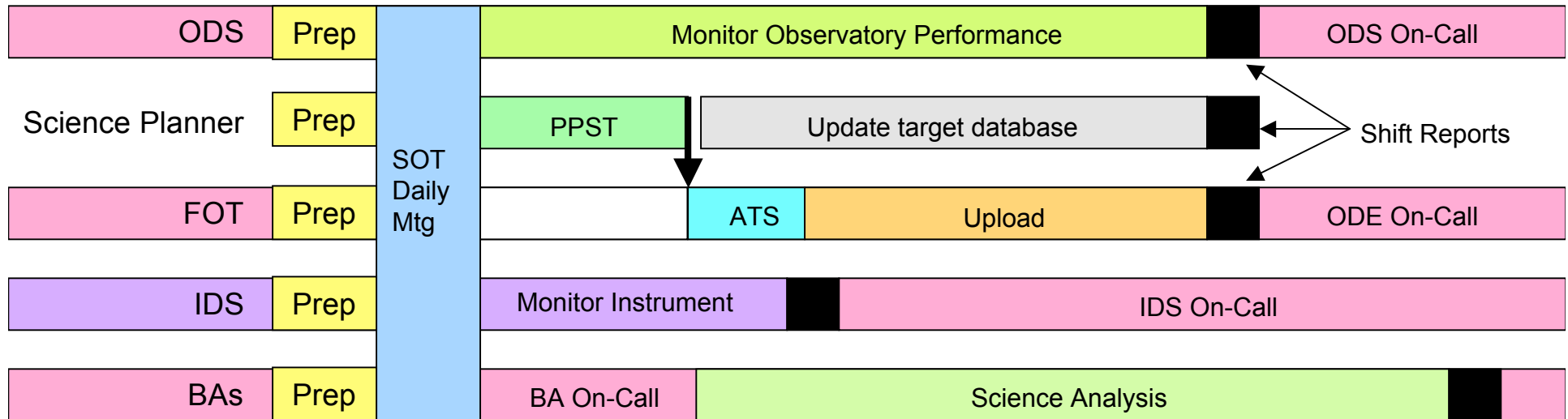
- Science Planner responsibilities:
  - Support daily science operations planning meeting
  - Plan and execute calibration observations
  - Prepare daily observing plans (PPST)
  - Update target data bases daily
  - Update target id / obs segment database daily
- Science Planner Personnel (all at PSU):
  1. David Burrows (XRT Lead, SOT Lead)
  2. Pete Roming (UVOT Lead)
  3. Jamie Kennea (XRT Scientist)
  4. Sally Hunsberger (UVOT Instrument Scientist)
  5. Claudio Pagani (XRT Science Team)
  6. David Morris (XRT Science Team)
  7. Mariya Ivanushkina (UVOT Science Team)
  8. Judith Racusin (XRT Science Team)



# SOT Daily Schedule



Eastern Time: 8:00 9:00 10:00 11:00 12:00 1:00 2:00 3:00 4:00 5:00 6:00

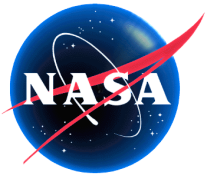


## Observatory Duty Scientist

- ☐ 8:00: Review observatory status
- ☐ 9:00: Daily SOT planning meeting
- ☐ 10:00 – 5:00
  - Monitor observatory status
  - Monitor progress of pipeline processing
  - Verify successful timeline upload
- ☐ 5:00: File shift report
- ☐ **ODS On-call**
  - Observatory anomalies via SERS
  - GRB alerts via GCN

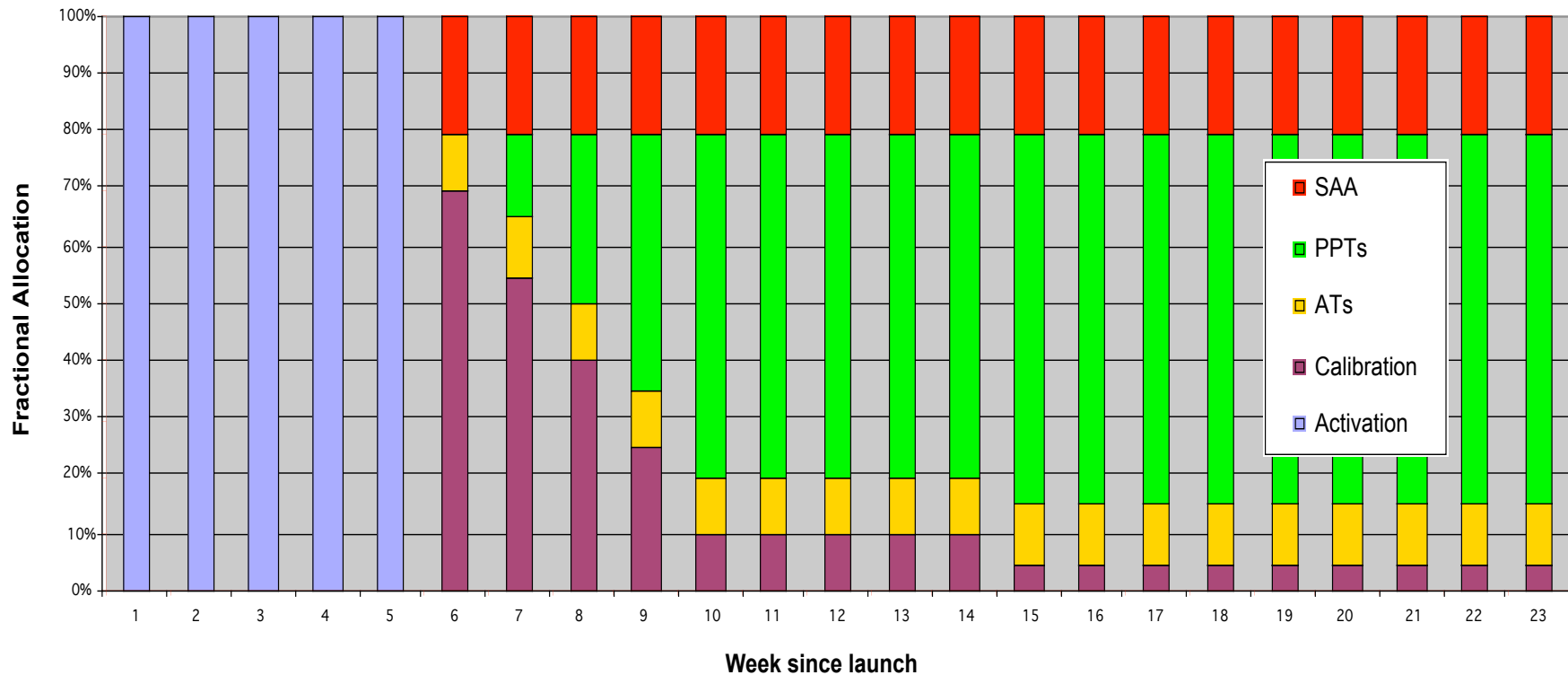
## •Science Planner

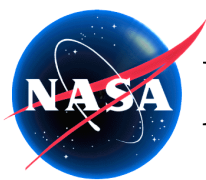
- 8:00: Review observing timeline status, new GRBs
- 9:00: Daily SOT planning meeting
- 10:00 – 10:30: Setup
  - Evaluate fields for bright sources, Assign UVOT modes
  - Add new targets to database
- 10:30 – 11:50: Preparation of PPST
- 11:50 – 12:00: Generate BAT Auxiliary Timeline
- 12:00: transfer final PPST to FOT
- 1:00 – 5:00: update target databasetimeline



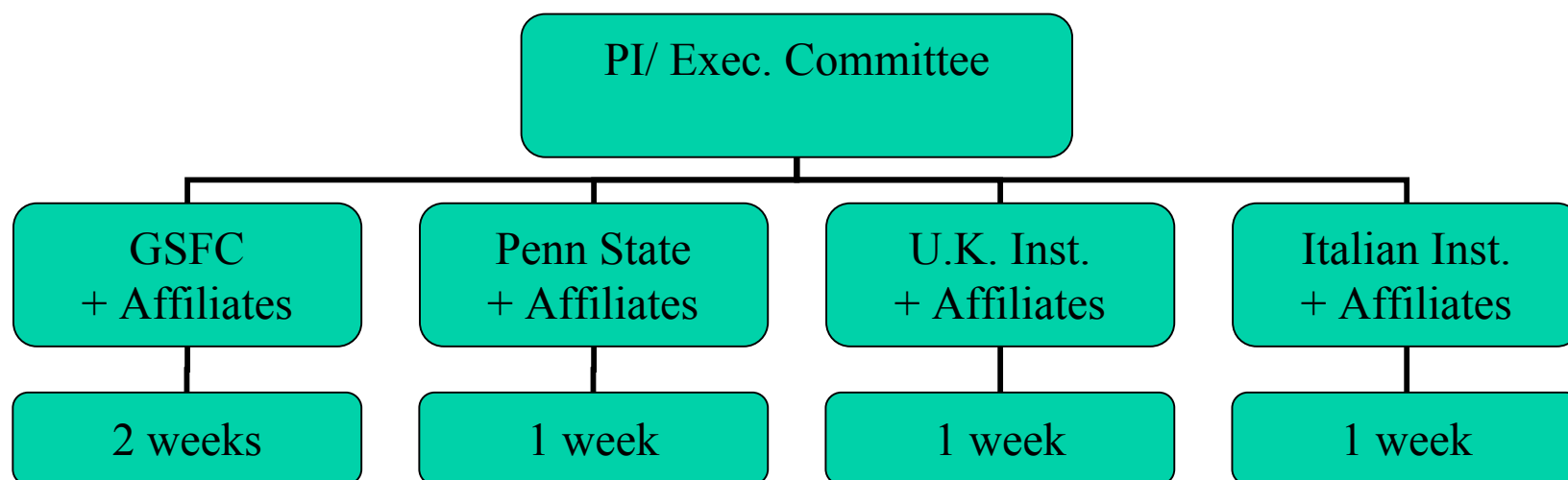
# Nominal Time Allocations *Swift*

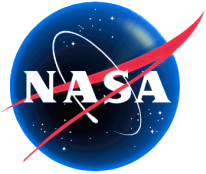
Fractional Time Allocations





# Management of Burst Advocates

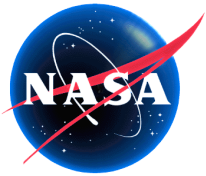




# Targets of Opportunity



- ToO's can be uploaded through TDRSS link at any time
- Non-Swift discovered GRBs can be uploaded as ToOs
  - Response timescale in minutes
- GRB observations can be extended via ToO without new command load cycle
- Procedure
  - ToOs submitted via Web form
  - Filtered for time-criticality
  - Science Operations Team reviews for feasibility
  - PI (or Designate) Reviews for Priority
  - Requestor rapidly informed of decision



# The Swift Gamma Ray Burst Explorer:

## Catching Gamma Ray Bursts on the Fly



*"Flight very rapid, 'twinkling',  
sailing between spurts."*

– Roger Tory Peterson

*"Swifts fly expertly on their first  
try. Regardless of their introduction  
to flight, all young are adept at it  
soon after they take their initial  
leap."*

– National Geographic Society

